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ABSTRACT

A symposium was organized to reexamine the realities of vertical proliferation between the United States and the Soviet Union and to place into perspective the horizontal proliferation of nuclear weapons throughout the world, including the possible role of commercial nuclear power in facilitating proliferation. The four invited symposium presentations are provided in this monograph. They include: "Nuclear Power and Nuclear Weapons: The Connection Is Tenuous" (Bernard I. Spinrad); "Nuclear Power and Nuclear Weapons: The Connection Is Dangerous" (John P. Holdren); "Horizontal Proliferation: The Spread of Nuclear Weapons to Other Countries" (Gene I. Rochlin); and "Vertical Proliferation: The Nuclear Arms Race of the Superpowers" (Herbert F. York). Among the areas/issues addressed in the first three papers are: weapons efficacy of materials from nuclear power reactors; nuclear power and world tension; nuclear policy alternatives; motivations and barriers (technical, economic, political) to acquiring nuclear weapons; history of power-related proliferation and prospects for further proliferation; Nuclear Non-Proliferation Treaty (NPT); gradual erosion of the NPT regime; and future of NPT safeguards. The final paper reviews facts/data about the arms race, describes systematic relationships among the facts/data, and draws conclusions based on the relationships. (JN)

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based on a symposium
presented by the
Forum on Physics and Society
of the
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Nuclear Energy, Nuclear Weapons Proliferation, and the Arms Race

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Preface

The nuclear arms race is not a recent phenomenon. Since just after World War II, the United States and the Soviet Union have been engaged in a weapons marathon that could end in a nuclear catastrophe — a holocaust that would destroy the industrialized world in twenty-four hours. Technical specialists refer to the arms race between these two superpowers, each possessing ever greater degrees of overkill, by the disconcertingly colorless term "vertical proliferation." The original justification behind this nuclear weapons buildup was that it would deter war, and that mutual deterrence would lead to mutual security. However, the arms race has now escalated to the point where both nations, and indeed much of the rest of the world, have been brought to a position of permanent insecurity. Neither superpower can launch a preemptive strike that would disarm the other. Both would be destroyed in any massive nuclear exchange. Even worse, a worldwide nuclear war is most likely to come about by escalation from a regional conflict in which neither of the superpowers is initially involved.

During recent years, nuclear weapons have been acquired by an increasing number of countries besides the United States and the Soviet Union, and still other countries either have or could have the capability to acquire them. This continuing increase in the number of nations that are able to initiate or wage nuclear war has been called "horizontal proliferation." If it is a reasonable assumption that the probability of nuclear war is some function of the number of countries that possess nuclear weapons, the world thereby will surely become less and less secure. For it could take only a small number of nuclear explosives to provide the tinder to ignite a global conflagration.

Commercial nuclear power is also being adopted by more and more nations. How does this fact bear on the problem of horizontal proliferation of nuclear weapons? Is nuclear power strongly connected to the worldwide spread of nuclear arms, or is the connection remote? These issues were more or less quiescent in the public consciousness for a number of years, during the period of political detente between the United States and the Soviet Union. But they have now again risen to the forefront because of the recent escalation of tensions between the two countries.

A symposium focusing on these issues was convened by the Forum on Physics and Society of the American Physical Society (APS), on January 26, 1982, during the joint meeting of the APS and

the American Association of Physics Teachers (AAPT), held in San Francisco. Its purpose was to reexamine the realities of vertical proliferation between the two superpowers and to place into perspective the horizontal proliferation of nuclear weapons throughout the world, including the possible role of commercial nuclear power in facilitating proliferation. This monograph was prepared from tape-recorded transcripts of the four invited presentations of the symposium.

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Nuclear Power and Nuclear Weapons: The Connection is Tenuous

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Introduction

Four main arguments will be presented to support the position that there is, at best, a tenuous connection between nuclear power and nuclear weapons. First, there is essentially no technical barrier to making nuclear weapons. The technology of nuclear weapons production from facilities that are not part of a nuclear power complex is cheap, simple and relatively easy to hide. It is available to most countries with use of indigenous resources and personnel.

Second, nuclear power presents more discouraging factors than encouraging ones as a route to proliferation. Nuclear weapons made by diverting materials from nuclear fuel-cycle operations, although possible, are inferior to those specially produced from dedicated weapons facilities. Nuclear power plants make an awkward cover for weapons production, as they are part of an open industry and diversion would be difficult to hide.

Third, the only effective barriers to non-proliferation are institutional, and depend on national and world consensus that proliferation is unsafe and not useful, and on actions to build and maintain such a consensus. Institutional factors have worked, and continue to work, toward making nuclear power an alternative to rather than a route to nuclear armaments.

Fourth, for over twenty-five years, nuclear power has been instituted in many countries as a trade-off against nuclear weapons. Most of the world's institutions for controlling the spread of nuclear weapons are in fact based on specific commitments of help in developing nuclear power in return for eschewing nuclear weapons.

No Technical Barriers to Nuclear Weapons

Almost any country that wants to make nuclear weapons has the capacity to do so, and would find the route of specialized production facilities attractive. Lower levels of technical sophistication, financial commitment, and uranium supply are required for specialized production than for nuclear power.

Only the truly technically advanced countries (plus the two giants, China and India) can produce nuclear power reactors. In contrast, the technical know-how to build special production facilities is very widespread, a fact that can be appreciated by recalling that the original production of nuclear weapons was accomplished with technology that is now forty years old. In 1949 the Netherlands and Norway, two countries ravaged by World War II, successfully built reactors that could have been used for plutonium production. Yet it is not the reactors themselves that are the major issue, but rather the auxiliary facilities that are part of the fuel cycle, such as enrichment and reprocessing plants. Today, any country that has a major engineering school must be considered capable of making special production reactors and high-enrichment isotope-separation plants, and there are at least 50 such countries. These facilities are not only simpler and cheaper to build than power reactors, but they can be relatively easily hidden in remote areas because their existence need not be publicized.

Uranium for weapons can be readily supplied just about anywhere on earth. It takes only one thousand tons of natural uranium to produce over 4 metric tons of separated U-235 by isotope separation, or over 800 kilograms of high-quality Pu-239 by loading into production reactors. Either way, this is enough for hundreds of nuclear bombs. At least two dozen countries in the Western world have uranium-ore reserves in excess of one thousand tons, and in many countries lacking ores, uranium-bearing shales of sufficient quantity are common. Table 1 lists the known uranium-ore (higher concentration) reserves of the Western world.[1]

Weapons Efficacy of Materials from Nuclear Power Reactors

Although it is possible to build a nuclear weapons arsenal by diverting facilities and materials from nuclear power fuel-cycle operations, world experience with the nuclear era has produced no examples of this type of diversion to date. The major technical

reason for this is that weapons procured by diversion would be inferior to those specially produced, both because of their greater radioactivity, which leads to fabrication and storage problems, and because of their lesser reliability and explosive yield. These disadvantages arise mainly because the fissile isotopes produced from power-reactors are of much lower purity than those produced from special production facilities.

In the design of nuclear explosives, two nuclides made in reactors are to be contemplated as weapons material: U-233 and Pu-239. U-233 is made in reactors by the irradiation of thorium (Th-232). Short irradiations of thorium produce a good material for small weapons. However, conventional power reactors operate on a single fuel loading for a long time, and those using a thorium-conversion cycle will build up significant quantities of U-234 and a troublesome amount of U-232 in addition to the desired product, U-233. (Typically, if half the Th-232 is permitted to fission, the recovered uranium will contain about 20% U-234. U-232 is formed, at least partly, by in-reactor (n,2n) reactions with the fuel, and its relative amount also increases with irradiation time.)

The problem with U-234 in weapons material is primarily that it is a diluent of U-233, which increases the critical mass of the explosive, hence the difficulty of fabricating a weapon. The problem with U-232 is that its radioactive decay (alpha decay) produces daughter products that have extremely penetrating radiation (gamma-rays). Weapons made from material containing comparatively large amounts of U-232 present a handling problem for tactical use because of the heavy radiation fields that are created, and a design and storage problem because of the need for heavy shielding to avoid damage of radiation-sensitive components.

With plutonium, the nuclide desired for weapons material is Pu-239, and the undesirable nuclides are Pu-238, Pu-240 and Pu-241. The rate of buildup of these latter nuclides in a U-238 conversion cycle for a power reactor is much greater than that of U-234 in a thorium system. Plutonium recovered from power-reactor fuel might typically contain 2% Pu-238, 25% Pu-240, and 10% Pu-241, in addition to the main product, Pu-239.[2]

Pu-240 presents two problems to the weapons maker. The first is the dilution effect already noted in the U-233, U-234 case. The second is that Pu-240 undergoes spontaneous fission, and is therefore a strong source of neutrons. For a maximum-yield bomb, neutrons are to be avoided until total assembly is achieved so that the chain reaction, once initiated, can build up rapidly enough so that

maximum energy is generated before the resulting explosion dissassembles the critical mass. This is impossible if significant Pu-240 is present. The result is a much less effective bomb, and one that is considered to be poorly predictable. Pu-238 and Pu-241 present different problems. They have relatively short half-lives, and jeopardize the shelf life of fabricated plutonium metal, both because of heat generation within the metal and because of helium generation. Plutonium is not a strong or highly ductile metal, and both these effects cause its rapid deterioration and compromise its integrity for use in a nuclear bomb.

Nuclear Power and World Tension

The only truly effective barrier to proliferation of nuclear weapons is a consensus, enforced by international agreements and national education, that proliferation is extremely dangerous to the world's security and is simply not to be tolerated. Nuclear power can contribute to this consensus, because it is a positive factor in reducing one of the main sources of international tension: uncertainty over energy supplies, especially oil, and over the future situation and policies of the international oil oligarchy. The United States has lost considerable political strength because of its oil dependence, and the industrial nations of Europe and the Far East are even more oil-dependent than is the United States. In the third world, developing countries are simply being priced out of the oil market; the development aspirations of many are thwarted by the loss of financial flexibility caused by high oil payments, and by the decreasing ability of the advanced countries to provide assistance.

These causes of energy uncertainty can best be reduced by decreasing the world's dependence on oil. Nuclear power, by supplying international energy, and by providing relief from the continued financial and political problems caused by oil-dependence, can contribute to defusing the war-detonating potential of the oil market. By thus diminishing the causes of war, nuclear power reduces the desire of countries to acquire nuclear weapons. Although it is not a panacea in this regard, nuclear power could be a major factor if the other issues impeding it use could be resolved, since the technical capability for rapid buildup exists and could be utilized in a benign policy setting.

The Nuclear Power - Nuclear Weapons Trade-Off

From the beginning of the nuclear era, there has been tension between those who believed that nuclear power was a major benefit to be offered nations that would abnegate nuclear weapons, and those who opposed nuclear power because it might be exploitable for nuclear military purposes. In 1947, the United States put itself squarely behind the former argument when it proposed its international development program for nuclear power, the Acheson-Lilienthal plan. Although at that time the idea of comprehensive international collaboration on nuclear power fell victim to Soviet opposition, it was revived in 1955 with the Geneva Conference on Peaceful Uses of Atomic Energy and the formation of the International Atomic Energy Agency (IAEA). Both the IAEA and the more recent Nuclear Non-Proliferation Treaty explicitly rest on the value of the trade-off of the benefits of nuclear power for safeguards against proliferation. Table 2 is a chronology of events relating to efforts at demilitarizing nuclear energy, and of international agreements on arms control more generally.

No country has ever spun off a nuclear weapons program from a nuclear power program; all historical examples are the other way around. By the time of the 1955 Geneva Conference, the Soviet Union and the United Kingdom, in addition to the United States, had demonstrated a nuclear weapons capability, but they had not yet developed commercial nuclear power. These countries were also subsequently the first to announce the production of nuclear electricity; in all three countries, with few exceptions, the power facilities were adaptations of reactors designed for weapons-material production.

France soon declared itself to be a nuclear weapons country, and began building up its isotope enrichment and plutonium production facilities. This declaration preceded any development of nuclear power. As we know, the French effort was completely successful, without any help -- indeed, with maximum discouragement — from the United States. A country still impoverished from World War II, France was the first to prove that a country that wants the bomb can make it with its own resources.

In spite of the lifting of secrecy that followed Geneva 1955, no other country joined the ranks of nuclear-weapons states for many years. Two reasons are credited for this period of non-proliferation. The first was the realization that the Russian and American arsenals of hydrogen bombs were already a world menace,

and that proliferation by other parties could act as a detonator for that menace. The second was the realization, vigorously promoted by the IAEA, that nuclear power could be obtained without building nuclear weapons. The instrumentality for this realization was a specific trade-off, originated by the United States and United Kingdom, expanded by the Soviet Union to countries in its political sphere, and later accepted by France. The trade was for assistance in the form of nuclear fuels and nuclear technology for civilian purposes, in return for which bilateral and multilateral inspections were required, so that this assistance could not be subverted into weapons. As a result, the period 1955-1969 was noted by a burgeoning of projects and plans for nuclear power, around the globe.

Only a handful of countries have behaved suspiciously in this regard. Indonesia and Taiwan were believed to have had weapons ambitions during that period, but if they did, these were firmly squelched by their sponsoring countries, the U.S.S.R. and U.S.A., respectively. Israel clamped secrecy over a research reactor that might be in use for weapons-material production; and India has detonated a nuclear explosive device, while even then maintaining that it had no intention of manufacturing nuclear weapons. One other country, South Africa, has also been accused of such intentions. In none of these cases has there been any suggestion that civilian power was the lure to the suspected capability, although Taiwan, India, and South Africa all have active power programs which could conceivably have been, or still be, "covers" for actions that were diplomatically embarrasing.

Policy Alternatives

Three possible alternatives for nuclear policy in regard to proliferation are:

(1) Continuation of the traditional policy that encourages the power/weapons trade-off with such strengthening of safeguards as are negotiable, whenever negotiations are feasible.

(2) Removing the trade-off from the list of non-proliferation tactics, but otherwise continuing existing policies as above.

(3) Returning to a policy of national insularity with regard to nuclear energy, and using non-nuclear "carrots and sticks" as incentives for non-proliferation.

The first is the most workable alternative. It amounts to recognizing the world as it really exists, and trying to improve it incrementally as opportunity permits.

The second alternative is close to what was tried by the Carter administration. It failed. Although it is not clear whether the failure was due to intrinsic flaws in the policy or to poor management, its result was to weaken the instrumentalities of the previous period by what amounted to a withdrawal of the United States from its traditional position as a principal supplier of nuclear power. Other countries rushed to fill the void and the international nuclear market became anarchic. Most importantly, the moral persuasiveness of the Non-Proliferation Treaty was much weakened when the United States attempted to change the treaty unilaterally.

The third policy is one of nuclear insularity that failed in the post-World War II years. It is conjectural whether the substitution of non-nuclear incentives for nuclear ones will ever work. Other countries supplying nuclear power are unlikely to accept such a policy, and countries who are customers for power will want to make their own judgments as to whether or not nuclear power is good for them.

Scenarios for Proliferation: Lures and Covers

In this section, we examine critically the two kinds of scenarios that have been constructed in which nuclear power acts to promote nuclear-weapons proliferation.

The first is the "lure," or attractive nuisance, scenario. A peaceful country acquires or builds up a nuclear power industry. Later, as the result of political change, it becomes more belligerent. It notes that by diversion of materials from the channels of nuclear power it can build up a large weapons capability rapidly. If it had to start from the ground up, this country might not have opted for nuclear weapons, but this opportunity swings the decision in favor of a weapons program.

The second is the "cover story" scenario. A country has the initial desire to acquire nuclear weapons but finds that it is impossible to announce this desire, for political or diplomatic reasons. It therefore builds up a large nuclear power industry, one

that justifies the existence of a national enrichment and reprocessing capability. Then, by open or clandestine diversion of materials from these facilities, it embarks on a program of weapons production.

The possibility that these scenarios will come to pass cannot be disproved. One can, however, examine their plausibility by trying to adapt them to specific situations. We do this by classifying countries into four types: advanced industrialized countries; large industrializing countries; small countries; and a special group of "pariah" countries whose national existence is at stake.

Are there any advanced countries for which either of these scenarios is realistic? One can conceive of a Germany in which a new Hitler came to power, or a Japan headed by a new Tojo, but only under a situation of a severe and extended economic depression and a breakdown of democratic institutions -- a highly unlikely, but not unimaginable scenario. However, if such advanced countries did decide to build domestic nuclear arsenals, they would almost certainly also decide to obtain the best weapons materials for the most modern weapons. France's nuclear weapons program, with its specialized facilities, is the most likely example. These possibilities are not especially worrisome, because the advanced industrial countries are precisely the ones who are most aware of and concerned about their jeopardy under nuclear war.

Consider, then, large industrializing countries such as India or Brazil. An implied Brazilian setting has in fact been used for a movie that acted out a diversion scenario in the "cover" category, and India has actually exploded a nuclear device. Although nuclear weapons would be of little actual military value to such countries, they can function as symbols of national strength, or machismo. But machismo is not served by secrecy; on the contrary, an "I did it all by myself" attitude is essential (e.g., the Indian example). The world is least likely to overlook the nuclear weapons efforts of such countries if they are achieved by treaty-breaking, whereas the response has been and would be more equivocal if their weapons programs were outside the scope of international agreements. (Witness how much of the world's indignation about India's nuclear explosive was focused on the actually irrelevant question of whether it was American or Canadian assistance that was perverted to make it possible.)

In the general group of small countries, one can imagine such situations as Iraq or Algeria — countries who have historical conflicts with their neighbors. For such countries, a small arsenal of

nuclear bombs might be considered sufficient to "cow" their enemies. The lure scenario is inappropriate for them, because they are unlikely ever to have legitimate reasons for constructing enrichment or reprocessing plants themselves. The cover scenario, however, is more appropriate, and could be of real concern.

Finally, there are the pariah countries: those who are rejected by other countries in their region (e.g., Taiwan, South Africa, Israel) or those who are ruled by recognizably unstable leaders (Khadaffi's Libya today, Amin's Uganda of yesteryear). Their situation as pariahs ensures that there need be no lure for them to engage in a nuclear weapons program. The cover scenario could conceivably be used, but the veneer would likewise be thin; and indeed, all suspicions of weapons activity in these countries have been focused on clandestine activities, rather than on the appurtenances of nuclear power, which are public. One exception might be the South African enrichment plant, which could be a weapons-material production facility, but is claimed to be needed — as well it might be — for the production of slightly enriched fuel for power reactors.

This exercise in plausibility specification can now be summed up. The lure scenario is implausible; not a single category of country yields an example where it makes sense. The cover scenario has some plausibility, primarily for small countries that might have interests in procuring one or a small number of nuclear bombs. Fortunately, these are countries for which international safeguards are most likely to be efficient, since the facilities concerned would be few in number and international action against violation is most likely to be implemented.

The world is well served by the trade-off offered by the International Atomic Energy Agency and the Non-Proliferation Treaty: assistance in the development of peaceful nuclear power in return for eschewing nuclear weapons. The economic benefits of this trade-off are real, and even a small contribution to decreasing the causes of world hostility far outweighs the very small risks of these scenarios. The world cannot afford to have fears of "what if" take the place of realistic assessments. World peace and stability are jeopardized by threats to the weapons/power trade-off, whether the threats arise from unilateral reinterpretations by supplier countries or from mingling of the weapons and power programs of weapons states.[3]

Notes

1. Nuclear Energy Agency (OECD) and International Atomic Energy Agency"Uranium Resources, Production, and Demand," IAEA (1979). The numberscited in this series of reports have tended to be understated, as they do not reflect deposits in countries that have not been explored, whether or not geological and geochemical settings have been evaluated.
2. M. Benedict, T. Pigford, and H. Levi, "Nuclear Chemical Engineering,"Second Edition; Chapter 8, Table 8.5, p. 370, McGraw-Hill (1981). The numbers in the text have been rounded off from values derived from this table.
3. Many of the themes of this presentation were originally presented by E. Zebroski in "Routes to a Nuclear Future with International Safeguards," Proc. Institute Nuclear Materials Management, (June, 1977). See also Proc. American Power Conference, Vol. 39, p. 26, (April, 1977), paper co-authored with C. Starr.

TABLE 1

WORLD DISTRIBUTION OF URANIUM*

	REASONABLY ASSURED RESOURCES TO 30 $/LB	TOTAL ASSURED PLUS ESTIMATED
ALGERIA	28	28+
ARGENTINA	21	60
AUSTRALIA	213	293
BRAZIL	10	19
CANADA	166	585
CENTRAL AFRICA REPUB.	8	16
DENMARK (GREENLAND)	6	16
FINLAND	2	2+
FRANCE	55	95
GABON	20	30
GERMANY	1	5
INDIA	29	52
ITALY	1	2
JAPAN	7	7+
KOREA	6	6+
MEXICO	6	6+
NIGER	50	80
PORTUGAL	7	7+
SOUTH AFRICA	276	350
SPAIN	104	211
SWEDEN	300	300+
TURKEY	3	3+
UNITED KINGDOM	2	6
UNITED STATES	454	1266
YUGOSLAVIA	7	22
ZAIRE	2	3+
TOTAL (ROUNDED) THOUSANDS OF TONS	1810	3470

*JOINT REPORT ON URANIUM RESOURCES OECD AND IAEA. DECEMBER 1975. EXCLUDES USSR AND CHINA

TABLE 2

STEPS TOWARD CONTROL OF NUCLEAR WEAPONS

INTERNAT'L AGREEMENTS ON ARMS CONTROL		DEMILITARIZING NUCLEAR ENERGY
1. ANTARCTIC TREATY 1959	1945	BARUCH PLAN FOR INTERNATIONAL CONTROL (TRUMAN-ATLEE-KING PROPOSALS)
2. LIMITED TEST BAN TREATY 1963	1946	RUSSIA REJECTS - WILL CONSIDER ONLY ON BASIS OF EQUALITY
3. OUTER SPACE TREATY 1967	1946	U.S. WITHDRAWS COOPERATIVE AGREEMENTS - BRITAIN (FRANCE)
4. TREATY FOR THE PROHIBITION OF NUCLEAR WEAPONS IN LATIN AMERICA 1967	1953	(DECEMBER) EISENHOWER-STRAUS PLAN, ATOMS FOR PEACE
5. TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS 1968	1954	ATOMIC ENERGY ACT
6. SEA-BED ARMS CONTROL TREATY 1971	1955	GENEVA CONFERENCE
7. BIOLOGICAL WEAPONS CONVENTION 1972	1956	INTERNATIONAL ATOMIC ENERGY AGENCY
8. SALT-ABM TREATY (SALT I) AND SALT INTERIM AGREEMENT		-WORLDWIDE SAFEGUARDS PLAN IAEA-CIR-66
9. SALT-II 1979		-CIVILIAN/MILITARY DISTINCTIONS -EURATOM SAFEGUARDS SYSTEM

Nuclear Power and Nuclear Weapons: The Connection is Dangerous

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Introduction

In the past few years, blue-ribbon reviews in several countries have viewed with alarm the link between nuclear power and the spread of nuclear weapons capability among nations. For example, the 1977 report of the Nuclear Energy Policy Study Group of the Ford Foundation, whose authors included an impressive array of senior U.S. defense analysts, stated:

> The consequence of nuclear power that dominates all others is the attendant increase in the number of countries that will have access to the materials and technology for nuclear weapons.[1]

The widely quoted British study, Nuclear Power and the Environment (the 1976 Report of the Royal Commission on Environmental Pollution), had this to say:

> The spread of nuclear power will inevitably facilitate the spread of the ability to make nuclear weapons and, we fear, the construction of these weapons.[2]

And the Australian national inquiry into whether that country should continue to mine and export her uranium for the purpose of nuclear power generation in other countries (the Ranger report) concluded:

> The most serious danger in our view is that of proliferation of nuclear weapons.[3]

None of these eminent groups could reasonably be called "antinuclear". They simply were trying to characterize fairly the liabilities of nuclear power as elsewhere in their reports they tried to characterize its benefits, so that those making decisions about the use of this energy source would be able to do so on the basis of complete information. This is my goal as well. I do not claim that nuclear power's "weapons connection" manifestly renders intolerable the use of this energy source in all circumstances and for all time. I simply contend that a realistic appraisal of the weapons liability must be included, along with the best information about the other

costs and benefits of nuclear power and of the alternatives to it, in any sensible evaluation of energy strategies.

Acquiring Nuclear Weapons: Motivations and Barriers

Some analysts try to dispose of the weapons connection of nuclear power by arguing that weapons proliferation is mainly (or even purely) a "political problem".[4] Their argument goes something like this: The motivation for acquiring nuclear weapons is political; the technology for acquiring nuclear weapons cannot be controlled in any case; therefore, the only practical preventative actions are political ones that reduce the motivations.

The point about motivation is substantially correct, but the rest of this line of argument is simplistic, inconsistent, and misleading. It ignores the nonpolitical (technical and economic) barriers to acquisition of nuclear weapons, as well as implicitly oversimplifying the political ones. It dismisses a wide range of options by which the spread of weapons-relevant technology could be slowed, as if anything short of stopping proliferation completely were not worth doing. It does not subject the political measures it endorses to the same standard of perfection implicit in its rejection of technological measures. And it begs entirely the question of the costs of failure: What weight should be given, in society's energy decision-making, to the possibility that the best attainable combination of political and technological measures will not prevent some acceleration of the spread of nuclear weapons in consequence of the spread of nuclear power?

A less simplistic approach to the problem must recognize the interaction of motivations and barriers to weapons acquisition, and must try to understand how the presence of commercial nuclear power affects that interaction. I see the key relations as follows. The rate of increase in the number of nuclear-armed nations depends on the strength of the motivations for nuclear-weapons acquisition (which are mainly political) relative to the height of the barriers (which are political, economic, and technical). If a country is sufficiently motivated to acquire nuclear weapons, it will succeed eventually in doing so, with or without the help of commercial nuclear power. But smaller motivations suffice to justify a decision for nuclear weapons in nuclear power's presence than in its absence, because it unavoidably lowers the barriers in important respects.

Let us look more closely at these barriers and at how nuclear power influences them.

Technology

The main technical barriers to acquisition of fission weapons do not include the "secret" of how to design such a bomb, for that information is so widely distributed that it must be presumed to be readily available to any and every interested nation.[5] (Fusion bombs are a different matter, which I shall not discuss further here.[6]) Rather, the main technical barriers are a weapons program's requirements for a sizable cadre of highly trained people (physicists, chemists, engineers of several varieties, technicians, technical managers) and for a source of weapons-usable material (generally meaning both a source of raw material and facilities for converting it to weapons-usable form).

A commercial nuclear power program lowers these barriers in three ways. First, even in its formative stages (before any electricity is being generated), such a program puts in place trained people of the same kinds needed for a weapons program, and it melds them into a working unit. Second, a nuclear power program cannot avoid solving the problem of raw material, typically doing so on a small scale at the research-reactor stage that precedes commercial operations, and necessarily doing so on a large scale at the commercial stage. Third, a power program often provides directly the means for converting the raw fuel into weapons-usable material (as is the case when the country seeks "self sufficiency" in its nuclear program by installing uranium-enrichment or spent-fuel-reprocessing facilities); and, even if a country refrains at first from acquiring this capability, its possession of both raw material and personnel simplifies a later decision to do so.

The seriousness of the third aspect of the problem is sometimes disparaged with the contention that the plutonium produced in commercial reactor operations is unsuitable for use in military weapons. The idea is that the high content of even-numbered isotopes in plutonium from reactors operated to maximize power production will impose unacceptable penalties in yield and reliability of nuclear bombs made from it. Alas, this reassuring notion is doubly flawed. The first flaw is that, with suitable sophistication in weapons design, the performance penalty associated with "reactor grade" plutonium can be made very

small.[7] The second flaw is that one commercial reactor type in use in several countries—the continuously refuellable CANDU—provides its owners the alternative of minimizing the content of the troublesome plutonium isotopes with little penalty in the economics of electricity generation.[8]

Economics

The economic barrier to development of a nuclear weapons program is, of course, the high cost of building and running facilities dedicated to weapons production. The economic issue often is formulated misleadingly, as follows: It is cheaper to build and run a plutonium-production reactor or centrifuge plant for uranium enrichment than to build and run a commercial nuclear power program.[9] This is a correct answer to the wrong question. The right question is: What is the marginal cost, for a weapons production program of any desired size, of doing it with the help of a commercial nuclear power program already in place, versus doing it with personnel and facilities dedicated exclusively to weaponry? Since much of the cost of the nuclear power program can be recovered from the sale of the electricity it produces, the answer is that the marginal cost of adapting a nuclear power program to produce bombs as well as electricity is less than the cost of building from scratch an equivalent weapons capability in facilities totally dedicated to that purpose. (The word "equivalent" is important here. The smaller plutonium-production reactors, whose modest cost often is touted in discussions of this issue, produce only a few bombs' worth of plutonium per year; a single large power reactor can produce twenty to fifty bombs' worth per year.[10])

If any more specific confirmation of the economic advantage of the commercial-power route to bombs is desired, it is unfortunately available in a most distressing form: the admission of the U.S. government, in late 1981, that it is itself considering turning to commercial-reactor fuel as the source of plutonium for a new round of U.S. nuclear warheads.[11] Is it conceivable that the U.S. government would even consider paying the political costs of such a move unless its economic attractiveness were compelling?

Politics

The political barriers against the acquisition of nuclear weapons are arguably the most important ones, even as political factors dominate the motivations.[12] A country may desire nuclear weapons to counter threats to its own national security, or to increase its capacity to achieve by force political objectives outside its boundaries, or simply to increase its prestige and influence in its region or globally. The main political barriers opposing such motivations are: (a) the concern that possession of nuclear weapons may increase a country's chances of having such weapons used against it; (b) the international "norm" against acquisition of nuclear weapons, including but not limited to the norm's concrete manifestation in the Non-Proliferation Treaty (NPT); (c) the possibility of divisive and even government-threatening internal dissent over a decision to acquire nuclear weapons; and (d) the possibility that such a decision will stimulate external sanctions and countermeasures — beyond the censure implicit in item (b) and besides the increased chance of nuclear attack considered under item (a).

Not all of these political barriers are lowered by the existence of an indigenous nuclear power program, but some are. Most importantly, a power program provides a legitimating cover for a set of nuclear activities which, without electricity generation as their manifest purpose, would be unambiguously weapons oriented. It is quite likely that a country embarking on a nuclear weapons program without the cover of a power program will be discovered and exposed, because many of the technical steps required are relatively easy to detect. If, on the other hand, a nuclear power program is in place, the country has a benign rationale for developing a cadre of nuclear-trained personnel, for acquiring large quantities of fissile materials, and for building the sorts of facilities that make it easy to transform these materials into weapons-usable forms.

In general, of course, a country that has acquired nuclear weapons must eventually make this fact known if it is to obtain the benefits that motivated the acquisition in the first place.[13] Why, then, would having the cover of a nuclear power program during the process of weapons acquisition matter? The main reason is that a country embarked on a weapons program is most vulnerable to both internal dissent and external countermeasures in the interval between making the decision and actually possessing the weapons. The earlier its intentions become known, the longer is the interval of

greatest vulnerability, the greater is the risk. A nuclear power program makes it possible to mask weapons intentions through all the early phases of establishing a weapons program and perhaps even into the phase of weapons stockpiling.

What is perhaps worse, a nuclear power program provides most of the ingredients of a nuclear-weapons capability even when no national decision to acquire weapons has been made. Thus, a nuclear power program established with wholly benign intent may become the vehicle for a rapid transition to nuclear-weapons status when internal political circumstances or external incentives change. In this respect, in fact, certain components of nuclear power programs — notably enrichment plants, reprocessing plants, and stockpiles of separated plutonium — must be considered "attractive nuisances" of a most dangerous kind: by making it so easy, they may constitute an irresistible temptation to acquire nuclear weapons under provocations insufficient to motivate undertaking a weapons program from scratch.

Victor Gilinsky, a member of the U.S. Nuclear Regulatory Commission and long-time analyst of nuclear power's weapons connection, captured the essense of the "barriers" problem when he wrote:

> The construction of a special-purpose plutonium production reactor signals a country's intention to build bombs; and, in the present climate, risks premature interception of its attempt to obtain explosive material for nuclear weapons. This risk can be avoided, however, by stockpiling separated plutonium from spent power plant fuel openly and legally. A defense establishment can design and fabricate a bomb in privacy; the illegal activity is then confined to a swift, almost one-step process: appropriation from its storage place of the necessary plutonium, fabrication, and insertion into the waiting bomb. It is surely the quickest, cheapest, and least risky route to nuclear weapons.[14]

History of Power-Related Proliferation

It is part of the conventional wisdom of the proliferation literature that none of the countries known to have acquired nuclear weapons to date have used power reactors as their means of taking this step.[15] This statement is strictly correct, but it misleads by fostering an artificial distinction between nuclear power reactors and nuclear power technology as a whole — including enrichment

technology, reprocessing technology, trained personnel, and infrastructure. The interesting question is whether the development and/or transfer of nuclear power technology -- including research facilities whose development or transfer was motivated or justified by the potential of nuclear electricity generation -- has contributed to the spread of nuclear weapons. Let us look briefly at the history of proliferation to see.

In the cases of the first three nuclear-weapons states -- the United States, the Soviet Union, and the United Kingdom -- civilian nuclear technology was an offshoot of the military technology, not vice versa. At the time these countries embarked on their weapons programs, there was no civilian nuclear technology on which to draw.

The next two nations to develop nuclear weapons, France and China, often are placed in the same category, but their cases are less clear-cut. The French nuclear program was at least ambiguous in its early years -- enough so that many of the scientists involved were able to believe it had only civilian purposes.[16] China's nuclear weapons program was developed on a technological foundation built with the help of the Soviet Union, which in 1957 initiated a program of nuclear-technology assistance to its less developed neighbor. Presumably, the Soviets were motivated by the idea that China would use this technology for the production of electric power. They terminated their nuclear assistance to China a few years later, probably upon becoming convinced that the Chinese were bent on making bombs instead of electricity.[17]

The last confirmed addition to the "club" of nuclear-weapons states was announced by India's 1974 detonation of a "peaceful" nuclear explosive. The plutonium for this explosive apparently came from a research reactor provided by Canada, which used heavy water supplied in part by the United States. That the source of the nuclear material was not a power reactor is scant consolation; for it is hard to believe that Canada and the United States would have provided a research reactor, heavy water, and other nuclear assistance to India for any other reason than to facilitate the development of commercial nuclear power in that country.

As Roberta Wohlstetter has argued, in fact, the Indian case is a concrete and compelling example of just the sort of "attractive nuisance" and "cover" syndromes that more complacent writers continue to find either "far-fetched" or "adequately precluded".[18] Wohlstetter writes:

Policy must principally address...the countries that can drift

> toward a military capability without any intention of arriving at it, and yet that may adopt a civilian program that ultimately places them within days of acquiring material for nuclear explosives. The Indian experience illuminates that process of drifting toward a bomb. Canadian and U.S. help — transfers of facilities, equipment and material, advisory scientific and engineering services, training of Indian personnel, financial subsidies and loans — formed a major ingredient of the Indian program that was shortening critical time to make an explosive. And this help was given before and after the Indians revealed a strong interest in nuclear explosives.[19]

The last sentence — and the rest of Wohlstetter's analysis — indicate that the "cover" provided by commercial nuclear power can be almost hypnotic in its effect on the suppliers of nuclear-technology assistance, who in this case carried bravely on despite clear evidence of the likelihood of misuse for weaponry.

Two additional countries, Israel and South Africa, are not officially nuclear weapons states but are widely suspected of either possessing nuclear bombs or being very close to possessing them. The presumed source of Israel's weapons material is a research reactor provided by France — again, not a power reactor, but nonetheless a transfer of nuclear technology surely motivated on the supplier's side by a desire to help the recipient develop commercial nuclear power. In South Africa's case, the most likely source of bomb material is highly enriched uranium obtained from technology it built with considerable help from the Federal Republic of Germany.

It must be added that the last five weapons or near-weapons states mentioned — France, China, India, Israel, South Africa — all are nonadherents to the Non-Proliferation Treaty.

Prospects for Further Proliferation

The other countries on nearly everyone's "worry list" of potential proliferators in the next decade or so--Pakistan, Argentina, Iraq, Libya, Taiwan, South Korea, Brazil--all have achieved this threatening status with the help of technology transferred to promote the civilian use of nuclear power.

Some observers think Pakistan will test a nuclear bomb within the year.[20] One likely source of the needed nuclear-explosive material is a centrifuge technology for uranium enrichment that

Pakistan obtained with considerable inadvertent assistance from Europe: a young Pakistani scientist working in the Netherlands for a subcontractor to a German-British-Dutch commercial enrichment concern was able to return to Pakistan with complete plans, specifications, and a list of suppliers of equipment for an advanced enrichment plant. Pakistan's other potential route to a bomb would use plutonium produced in its commercial-power-producing CANDU reactor, which was supplied, along with fuel, by Canada.

Argentina has power reactors from the Federal Republic of Germany and from Canada, plus a heavy-water plant from Switzerland. The Chairman of the Argentine Atomic Energy Commission has stated publicly that its technologists have the capability to construct nuclear bombs.[21] Neither Argentina nor Pakistan has ratified the Non-Proliferation Treaty.

Libya has ratified the NPT, but that country's obvious pursuit of nuclear weapons indicates how hollow such a commitment can be. With little evident economic rationale for nuclear-generated electricity, Libya has the largest number of nuclear engineering students enrolled in foreign universities, per capita, of any country in the world.[22] Such training, of course, is as meaningful a transfer of nuclear technology as the shipment of a reactor, and, like such shipments, its stated rationale is the promise of civilian nuclear power.

One could continue down the gloomy list of potential proliferators, detailing the links between their weapons possibilities and the technology they have obtained under the auspices of commercial power programs, but the examples provided so far will perhaps suffice to make the point. The sad fact is that, if the link between nuclear power and the spread of nuclear weapons can now be called "tenuous" by some, it is only because nuclear power already has spread the underpinnings of nuclear weaponry so widely that there is little further harm that could be done.

Can Anything Be Done?

In reality, the situation is bad but it could get worse. The possibility of its getting worse means both that the link between nuclear power and proliferation must still be considered dangerous, and that thinking about ways to diminish the danger is worthwhile.

It is true that the basic technical knowledge needed to develop nuclear weapons is already very widespread, that there are several

ways besides the further development of commercial nuclear power for countries to use that knowledge to acquire nuclear weapons, and that, therefore, countries that want such weapons badly enough can be expected to get them with or without the further assistance of nuclear power programs. On the other side of the coin: (a) there are still far more countries in the world that have not yet decided to acquire nuclear bombs than have decided to do so; (b) there are far more countries with small to nonexistent nuclear power programs than with extensive ones; (c) the extent to which nuclear power programs lower the barriers opposing the acquisition of weapons increases with the scale of the power programs. (Countries with big programs are more likely to want — and better able to justify — their own enrichment and reprocessing plants than are countries with small programs, and it is easier to divert significant quantities of bomb material undetected from a big program than from a small one.)

These latter considerations make clear the potential of the further spread and expansion of nuclear power to make things very much worse than they already are. It needs only to be added that, under some circumstances, the worsening could take the form of a flood of entrants into weapons-state status, rather than a trickle. One has only to ponder the potential for regional "domino effects" — or to consider the possible reactions of countries such as Japan and West Germany to threats to their interests from lesser powers that have come into possession of nuclear weapons — to begin to appreciate the possibilities.[23]

What can be done to reduce the danger? Six kinds of approaches, not all mutually exclusive, suggest themselves:

(1) Work to strengthen gradually the Non-Proliferation Treaty and the safeguards, administered under the NPT by the International Atomic Energy Agency, against weapons use of civilian nuclear technology. (This approach includes efforts to get the major weapons states to meet their obligations under Article VI of the NPT, which calls for good-faith negotiations toward nuclear disarmament.)

(2) Strengthen superpower guarantees against nuclear threats to the security of nonweapons states, in order to reduce the incentives of the latter to acquire their own bombs.

(3) Seek drastic upgrading of the NPT and international safeguards, including, for example, internationalization of regional enrichment and reprocessing facilities.

(4) Attempt to develop and promote more proliferation-resistant

fuel cycles for nuclear power generation.

(5) Take unilateral U.S. action — and, where possible, multilateral action with other nuclear-technology suppliers -- to restrict access to the most proliferation-prone technologies and to punish proliferative actions by withholding assistance and by other economic and political sanctions.

(6) Develop and encourage the worldwide use of energy options other than nuclear fission, including, for example, increased end-use efficiency, unconventional and dispersed sources of oil and gas, solid fossil fuels, geothermal energy, and renewable energy sources. (Some analysts believe that this approach actually should include increased use of fission power in the major weapons states, in order to free up oil and gas for use elsewhere and to provide some leeway against the global build-up of atmospheric carbon dioxide from all fossil-fuel combustion. Others insist that de-emphasis of fission in weapons states is essential both to make resources available for the alternatives and to set an example for other countries.)

This is not the place for a detailed exposition of the pros and cons of these different approaches; that is available elsewhere.[24] I wish to emphasize only two points.

First, none of the first five approaches is even close to being fully satisfactory. All of them have costs, risks, and holes. This verdict holds as much for the politically oriented approaches as for the technologically oriented ones. It does not mean that various combinations of these measures should not be tried. But the overwhelming likelihood is that the best attainable results will not suffice to prevent some acceleration of the spread of nuclear weaponry as a consequence of the spread of nuclear power. This likely contribution to weapons proliferation must be counted a significant cost of nuclear power, hence an important incentive to pursue, with greater vigor than would otherwise be warranted, the sixth approach -- the promotion of energy alternatives to fission. That approach, like the others, is not cheap or easy; but I believe its potential for diminishing further the grave hazards of weapons proliferation outweighs its costs and difficulties.

Second, I think the attractions of nuclear fission as an energy source for industrial and less developed countries alike, aside from its proliferation liability, continue to be widely overestimated. This overstatement of fission power's benefits leads in turn to overstating the inevitability of its continuing spread. In LDCs, nuclear energy's

usefulness is compromised by its scale, degree of centralization, and present restriction to electricity as the delivered energy form. (The most compelling energy needs in many LDCs are small in scale, dispersed, remote from electricity grids, and most readily served by portable fuels.) In industrial nations and in the industrial sectors of LDCs, nuclear power is much less able to replace oil — the scarcest and most politically troublesome conventional energy source — than is commonly supposed. The reason is that, in most countries, not much oil is used to generate electricity. (In the United States, only about 10 percent of oil use is for electricity generation, and only about 4 percent is for the base-load part of electricity supply that is replaceable by nuclear power.)

The argument that the world should turn to nuclear power to help prevent a war over oil is thus undermined by an unfortunate irony: nuclear power is arguably the fastest, cheapest, and politically safest way for a country that has it to acquire a sizable nuclear arsenal; but it is probably the slowest, most expensive, and least effective way to displace oil.

Conclusion: A Race Against Time

By lowering the barriers to proliferation in a world of some hundred-fifty nations with varying degrees of motivation to acquire nuclear bombs, the spread of nuclear power can hardly fail to boost some countries over the threshold. Some of the countries that topple in this way into the nuclear-weapons "club" might never have joined without the lowering of barriers provided by nuclear power. Others might have acquired nuclear weapons later by building a military nuclear program from scratch.

But the existence of "direct" routes to weapons, divorced from civilian power programs, should not reduce by very much our dismay about the danger of power-linked proliferation, even if we think that the "direct" routes eventually will become so easy that all countries with any interest in bombs will have them. For the proliferation hazard of nuclear power is precisely that it will speed up the spread of nuclear weaponry, leading to more countries with more bombs sooner than would have been the case without it. I believe, in this connection, that the only way to view the proliferation problem with any degree of hope at all is as a race. The race is between the growth of the chance of nuclear war, as some function of the number of countries possessing the means for it, and the reduction

of the chance of nuclear war through increased rationality in world politics. The latter needs all the time we can give it.

It is true that the way we handle nuclear power in particular and our energy affairs in general can, at best, only buy time against the proliferation of nuclear weapons. But that time may make all the difference.

Notes

1. Spurgeon M. Keeny, Jr., Seymour Abrahamson, Harold Brown, Albert Carnesale, Abram Chayes, Hollis B. Chenery, Paul Doty, Philip J. Farley, Richard L. Garwin, Marvin L. Goldberger, Carl Kaysen, Hans H. Landsberg, Gordon J. MacDonald, Joseph S. Nye, Wolfgang K.H. Panofsky, Howard Raiffa, George W. Rathjens, John C. Sawhill, Thomas C. Schelling, and Arthur Upton, Nuclear Power Issues and Choices, Report of the Nuclear Energy Policy Study Group (Cambridge, MA: Ballinger, 1977), p. 271.
2. Sir Brian Flowers, Chairman, Nuclear Power and the Environment, Sixth Report of the Royal Commission of Environmental Pollution (London: Her Majesty's Stationery Office, September 1976), p. 76.
3. R. W. Fox, G.G.Kelleher, and C.B. Kerr, Ranger Uranium Environmental Inquiry: First Report (Canberra: Australian Government Publishing Office, 1976), p. 178.
4. See, e.g., the paper by Bernard Spinrad, "Nuclear Power and Nuclear Weapons: The Connection is Tenuous", presented at this same symposium.
5. Theodore B. Taylor, "Nuclear Safeguards", Annual Review of Nuclear Science, vol. 25 (1976), pp. 407-421.
6. But see John P. Holdren, "Fusion Power and Nuclear Weapons: A Significant Link?", Bulletin of Atomic Scientists, vol. 34, no. 3 (March 1978), pp. 4-5.
7. This conclusion has been expressed in the open literature in the last several years by a variety of analysts with impeccable credentials. See, e.g., Theodore B. Taylor, op. cit.; Office of Technology Assessment, U.S. Congress, Nuclear Proliferation and Safeguards (New York: Praeger, 1977); and Victor Gilinsky, "Plutonium, Proliferation, and Policy", Technology Review, February 1977, pp. 58-65. Gilinsky, formerly head of the Physical Science Department at the RAND Corporation and

Assistant Director for Policy and Program Review of the U.S. Atomic Energy Commission, and now Commissioner at the US Nuclear Regulatory Commission, summed up the situation this way (p. 61): "The fact is that reactor-grade plutonium may be used for nuclear warheads at all levels of technical sophistication. In other words, countries less advanced than the major industrial powers but nevertheless possessing nuclear power programs can make very respectable nuclear weapons... The use of reactor-grade plutonium may impose a penalty in performance that is considerable or insignificant, depending on the weapon's design."

8. See, e.g., Keeny et al., op. cit., p. 280. A third flaw in the complacent view of "reactor-grade" plutonium will materialize if laser isotope separation becomes an inexpensive way to get rid of the unwanted isotopes in plutonium from light-water reactors.
9. See, e.g., Bernard Spinrad, op. cit.
10. Theodore B. Taylor, op. cit.; John R. Lamarsh, "On Construction of Plutonium-Producing Reactors by Small and/or Developing Nations" Nuclear Proliferation Factbook (Washington, DC: Government Printing Office, 1977), pp. 533-62.
11. Colin Norman, "Weapons Builders Eye Civilian Reactor Fuel", Science, vol. 214, pp. 307-308 (16 October 1981). Apparently trying to reconcile this idea with the longstanding contention of many in the present Administration that commercial nuclear power is not an economic way to obtain weapons, Kenneth Davis, Deputy Secretary of the U.S. Department of Energy, was quoted in Nuclear News (January 1982, pp. 40-41) as follows: "'We have always said that going to weapons through the power route is a costly and inefficient route to go.' But this does not say, he added, 'that once you are a weapons state you should not go that way.'"
12. Political motivations and barriers are explicated more fully in Ted Greenwood, Harold A. Feiveson, and Theodore B. Taylor, Nuclear Proliferation (New York: McGraw-Hill, 1977) and in Keeny et al., op. cit.
13. In some circumstances, however, a country may find its interests better served by a condition of ambiguity about its nuclear-weapons status than by acknowledgement of possession. See, e.g., Victor Gilinsky, "Diversion by National Governments", in Mason Willrich, ed., International Safeguards

and Nuclear Industry (Baltimore: Johns Hopkins Press, 1973), pp. 159-75.

14. Victor Gilinsky, "Nuclear Energy and the Proliferation of Nuclear Weapons", in Albert Wohlstetter, Victor Gilinksy, Robert Gillette, and Roberta Wohlstetter, Nuclear Policies: Fuel Without the Bomb (Cambridge, MA: Ballinger, 1978), p. 89.
15. See, e.g., Bernard Spinrad, op. cit., and Keeny et. al., op. cit., p. 280.
16. Lawrence Scheinman, Atomic Energy Policy in France Under the Fourth Republic (Princeton: Princeton University Press, 1965).
17. Office of Technology Assessment, U.S. Congress, op. cit.
18. Bernard Spinrad, op. cit.
19. Roberta Wohlstetter, "U.S. Peaceful Aid and the Indian Bomb", in Wohlstetter, Gilinsky, Gillette, and Wohlstetter, op. cit.
20. An excellent review of the Pakistani situation as well as other proliferation prospects is David K. Willis's series, "On the Trail of the A-Bomb Makers", The Christian Science Monitor, November 30-December 4, 1981.
21. Office of Technology Assessment, U.S. Congress, op. cit.
22. David K. Willis, op. cit.
23. A useful introduction to thinking about the possibilities and consequences of really extensive proliferation is J. K. King, ed., International Political Effects of the Spread of Nuclear Weapons (Washington, DC: Government Printing Office, April 1979), 234 pp.
24. See especially Gene I. Rochlin, Plutonium, Power, and Politics (Berkeley: University of California Press, 1979), 397 pp.; Amory B. Lovins, L. Hunter Lovins, and Leonard Ross, "Nuclear Power and Nuclear Bombs", Foreign Affairs, Summer 1980; Keeny et. al., op. cit.; Greenwood, Feiveson, and Taylor, op. cit.; Wohlstetter, Gilinsky, Gillette, and Wohlstetter, op. cit.

Horizontal Proliferation
The Spread of Nuclear Weapons to Other Countries

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Introduction

From the earliest days of the Atoms for Peace program, it has been recognized that development of even the most peacefully intentioned program in nuclear power technology begins to confer upon a country the potential for developing nuclear weapons. The larger, the more sophisticated, and the more diverse that program becomes, the greater the capacity to exploit that potential for weapons purposes. In thinking about horizontal proliferation — the spread of nuclear weapons among countries — one should keep in mind the important distinction between technical measures and barriers, designed to limit the spread of sensitive materials, processes, and skills that increase potential, and institutional measures and barriers, designed to prevent that potential from being put to use.

Less obvious, but no less important, is the need to make a parallel distinction between those political measures and barriers based on security and self-interest and those based upon common interests and broad values; that is, to distinguish between reducing motivation — which has to do largely with local and regional military and economic balance, alliance structures, and class and power struggles — and the establishment and strengthening of international norms.

Motivation can be addressed in a number of ways: positively, through means such as security guarantees, conventional arms, or technical assistance; or negatively, through threats or withdrawal of assistance or aid. In all cases, however, motivation and intent are addressed in specific and detailed terms tailored to individual countries and specific situations.

Strategies to create a self-organized, self-policed system of behavior that may be termed a non-proliferation "regime" — a set of international norms against the development of nuclear weapons —

are necessarily more general and less direct.[1] Whereas motivational strategies are inherently discriminatory and selective, a set of strategies addressed at international norms must be strong and consensual, and, therefore, as non-discriminatory as possible.

The Nuclear Non-Proliferation Treaty

Until 1970, there was no established international regime to limit nuclear proliferation, although during the 1960s a number of unilateral and multilateral restraints and safeguards had been applied to transfers of technology, materials, and equipment. It was in fact the increasing perception of the limitations of these kinds of strategies that led to the negotiation of the Treaty on the Non-Proliferation of Nuclear Weapons (usually referred to simply as the Non-Proliferation Treaty or NPT). The NPT came into force in 1970.

In the United States, the alarms were generated out of a number of studies that pointed up the great risks to world political stability and U.S. security that would be presented as an ever-increasing number of countries became capable of producing nuclear weapons.[2] In the Soviet Union, the main alarm was over the perceived threat that West Germany might become a nuclear power.[3] Thus, through a peculiar conjunction of disparate motives, the United States and the Soviet Union were able to agree that neither technology-controls alone nor the individual influences of the superpowers could be relied upon to limit the spread of nuclear weapons in the long run. The "solution" was an international treaty that also superimposed international rules of collective behavior. In the treaty's ideal form, every country ratifying would solemnly undertake neither to produce nuclear weapons itself nor to assist any other country to do so.

Such a non-discriminatory form was clearly impossible because five countries already possessed nuclear weapons and none was willing to give them up. Therefore, with an important and singular political innovation, the Non-Proliferation Treaty permanently institutionalized the separate and special status of the United States, the Soviet Union, the United Kingdom, France, and China. Under the treaty, these are the only nuclear-weapon states; all the rest are by definition non-nuclear-weapon states.[4]

This unique distinction is central to the entire set of rules, agreements, and behavioral norms that constitute the non-

proliferation regime the NPT was created to establish. If at some future date, for example, India should decide to sign and ratify the NPT, or in any other way to belong to the present non-proliferation regime, it will have to do so as a non-nuclear-weapon state. It is for this reason that India should not be too forcefully challenged on its claim that its explosion was a peaceful test and not a nuclear weapon. Likewise, Israel should not be pushed to "resolve" its careful and deliberately maintained nuclear ambiguity. To refer to either of these countries in any context as "nuclear-weapon states," would further discourage them from considering joining the regime, or even raise international objections that could close off the possibility of their doing so.[5]

Not surprisingly, the non-nuclear-weapon states demanded a considerable price for agreeing to an international treaty that discriminated between two kinds of states according to, as it were, their conditions of birth. At the level of technology and equipment, the nuclear-weapon states agreed to assist in the transfer of peaceful nuclear technology, primarily to guarantee that the discrimination would not be extended to the commercial level. The nuclear-weapon states also agreed to reduce the inequity of the treaty at the political level by undertaking "to pursue negotiations in good faith on effective measures relating to cessation of the nuclear arms race at an early date and to nuclear disarmament" and to seek "to achieve the discontinuance of all test explosions of nuclear weapons for all time." In return, the nuclear-weapon states demanded a strengthening of institutional barriers to proliferation, and accordingly a more comprehensive "full-scope" safeguards system was devised, to be administered by a greatly strengthened International Atomic Energy Agency (IAEA).[6]

Gradual Erosion of the NPT Regime

The period from the late 1960s to 1974 was one of relative consensus about the efficacy of the NPT, and complacency about the near-term risks of proliferation. This complacency was shaken by the Indian nuclear explosion in 1974, which showed that the less-industrialized countries did indeed have considerable capability, and broken soundly by the prospective nuclear export deals between West Germany and Brazil and between France and Pakistan and South Korea. This brought to sharp attention both the extent of the near-term threat of nuclear exports and the growing limitations on

the ability of the United States to control the nuclear trade through its own actions.

These developments caused intensive reconsideration and debate of the non-proliferation regime and its safeguard measures, and also major conflict among the nuclear suppliers and between them and their customers.[7] Unfortunately, neither the NPT regime nor its safeguards have adapted to changing perceptions of technical risk, to the steady erosion of confidence in institutional safeguards measures, or to the growing complaint that the nuclear-weapon states have failed to live up to their political promise to limit nuclear testing, let alone to reduce the risks of nuclear war.

At the technical level, the barriers between peaceful uses of nuclear technology and their application or conversion to weapons programs, which have heretofore been substantial, are being gradually eroded through many channels: the continued training and experience of personnel; the general increase in technical and industrial capabilities among the less-industrialized countries; the advent of newer and simpler materials-separation technologies; the emergence of "second tier" equipment suppliers (many of whom are among the small but important group of non-signers of the Non-Proliferation Treaty); the slow but sure diffusion of information about weapons design and performance, accompanied by a vast increase in relatively inexpensive and available computational ability; and the increased performance of available military hardware that can serve as an effective and controllable delivery system.

However, technical measures (such as materials accountancy) are not in and of themselves safeguards. Rather, they are the technical elements of the institutional system of safeguards, which is designed not to prevent diversion, theft, or the development of a weapons program, but to deter them by greatly increasing the probability that such activity will be detected and reported. There is no technical fix to the fallability of safeguards; no set of technical and institutional measures that are reasonably achievable can be absolutely foolproof.

The Future of Safeguards

The NPT safeguards, as administered by the International Atomic Energy Agency, are based upon confidence in the IAEA Inspectorate and its Vienna staff. But the IAEA is increasingly

perceived to have become politicized, at least partially because of its recent propensity to take sides in the debate over safeguards and the risk of proliferation. Moreover, the Agency, as a policer of international norms rather than of motivations, has an inherently global charter that tends to limit its freedom of action in cooperating with bilateral or multilateral measures (e.g., selective export controls or distinctions between "safe" and "dangerous" countries) that selectively target high-risk countries. As a result, the Agency, barely adequate to monitor even today's nuclear industry, is very unlikely to grow to the size that would provide a reliable and credible institutional barrier to a future industry based on the widespread use of plutonium. In this connection, it should be pointed out that despite the delay brought about by the worldwide slowdown in growth of the nuclear industry, most nuclear agencies, including the IAEA, still consider that a shift to plutonium-fueled fast-breeder reactors is not only desirable, but inevitable.

Consider the scale of the technical and institutional challenge that will be posed if this agenda is acted out. The initial fuel charge for a representative 1000 MWe plutonium-fueled, liquid-metal-cooled fast breeder reactor contains more plutonium than is produced by a light-water reactor of the same size over its entire lifetime.[8] Thus, the problem will shift from that of providing safeguards for a few stationary "plutonium mines" to that of inspecting and protecting, to a high degree of accuracy, numerous and diverse "plutonium rivers" flowing among the many required facilities. At that point, no reasonable system of safeguards is likely to be capable of doing more than verifying national methods of protection, which are likely to be aimed more at terrorist or insurrectionist groups than at governments themselves.

Motivation: the Key to Non-Proliferation?

The burden of limiting further proliferation, whether by diversion from civilian power uses or through a committed weapons program, will increasingly have to be placed on measures that are largely political. But, again, a distinction needs to be made between political measures that are aimed at the motivation and intent of individual countries and those designed to strengthen international norms and behavioral rules. These distinctions are as important as those, previously mentioned, between technical and institutional measures.

There is a vast body of literature and analysis about the intentions, capabilities, and motivations of individual countries that have not signed the Non-Proliferation Treaty (among which are India, Pakistan, Israel, Brazil, Argentina, and South Africa) as well as of those that have signed (among which are Libya, Iraq, and Taiwan). This has led to an increasing tendency to perceive the problem of limiting further proliferation as one to be addressed directly on an individual basis by the application of political leverage, power, and influence. But as capabilities increase and spread, and political and industrial power become more diffused in the world, these strategies are less and less likely to be successful. For every Taiwan whose behavior is to a considerable extent controllable by its arms supplier, there is likely to be at least one independently minded Brazil.

Furthermore, to the extent that such motivational and security-oriented measures involve the transfer of other weapons or the provision of individual security guarantees, they can actually increase overall risk by threatening to draw the nuclear powers directly into local or regional conflicts. Worst of all would be the provision of specific nuclear guarantees, which would, in political terms, introduce nuclear weapons into the region even if none of the countries involved possessed their own.

Specific, country-by-country measures to increase security or decrease motivation do have an important purpose, but they have not been the sole restraint on the countries that now have nuclear capability. Canada, Japan, West Germany, Italy, Belgium, and others have exercised a great deal of self-restraint — largely for internal political reasons, to be sure, but certainly aided by an international norm that judges nuclear weapons to be odious if not positively immoral. This norm had much to do with the decision of Sweden to abandon a nuclear weapons program that was already underway.[9] Even Israel and India have gone no further than was absolutely necessary in their view to achieve their own political purposes.

If the United States and the Soviet Union were unsure of their ability to restrain proliferation through unilateral and multilateral action as long ago as the 1960s, how is it possible to rely on such a strategy in the 1980s, in a world in which there are many more suppliers of technology and equipment, in which Western Europe and Japan are being asked to bear an increasing share of their defense, in which the less industrialized countries are everywhere attempting to assert their independence, and in which the sources of regional

and local conflict are becoming increasingly distinct from the confrontation between the superpowers?

Yet, with all the attention now being paid to motivational and security strategies, the United States and the other weapon states have almost completely failed to live up to their obligation under the NPT to reduce both the risks and the legitimacy of nuclear weapons by limiting their own testing, development, and global deployment. This, in fact, is the final link in the chain — the link between horizontal proliferation and "vertical proliferation" — the arms race between the superpowers.[10]

Loss of Credibility of the Superpowers

Failure to take any serious measures to slow, let alone halt, the nuclear arms race puts a serious strain on the credibility of U.S. negotiators, who must argue the risk of a few nuclear weapons in Latin America while the country deploys tens of thousands in Europe, and explain to others that nuclear weapons will not increase their security, while we continue to base our entire defense policy on them. The manifest reluctance of the nuclear-weapon states to impose any meaningful restraints on their own weapons programs provides a negative example that undermines all their public pronouncements about the risks and dangers of the further spread of nuclear weapons.

The nuclear-weapon states have not even lived up to their explicit promises made in conjunction with the NPT. The Threshold Test Ban Treaty is a game only between the United States and the Soviet Union. Moreover, the 150-kiloton limit is far above the capabilities of potential proliferators. France and China are not parties to the Limited Test Ban Treaty, or to the Non-Proliferation Treaty (although France has stated that it would act as if it were a NPT ratifier with regard to safeguards). The United States has only recently moved to complete the applicable protocols of the Treaty of Tlatelolco, which prohibits nuclear weapons in Latin America, and the Soviets appear to have done nothing to induce Cuba to sign, which is a key omission because the treaty requires that all states in the Latin-American region sign for it to come into force. SALT II was rejected by the U.S. Congress, and now the current Administration is threatening to delay START to "punish" the Soviets for their behavior toward Poland. It is easy to conclude from this list, particularly if you are a country in some other part of

the world, that limiting the spread of nuclear weapons is not a central concern to the superpowers.

The apparent unwillingness of the United States to expend the political capital necessary to restrain its own allies with regard to access to and export of sensitive fuel-cycle technologies and materials can only lend credence to the suspicion among many non-nuclear-weapon states that supposed non-proliferation policies are based more on the desire of advanced industrial countries to maintain their continued technical and political dominance than over the supposed risks to security, the environment, and human life.

In particular, the inability of the United States to resolve the tension arising from its simultaneous nuclear promotion, alliance, and nonproliferation policies has led the country to offer elaborate and convoluted arguments for not firmly opposing the possession of sensitive technologies and weapons-usable materials by its advanced industrial allies such as Japan and Germany. But if such countries are to be deemed "safe" primarily on the grounds that they could in any case make nuclear weapons on their own, this rationale does more than just erode the norm by applying a double standard. It leads other countries to ask whether they too might be able to gain some commercial advantage by demonstrating at least the capability to manufacture nuclear weapons themselves. To date, the nuclear suppliers who continue to insist on the primacy of the norm have failed completely to order their own policy priorities and choose among these alternatives, each of which has certain risks: continuing to impose restraints on their advanced allies, introducing a new and more subtle form of discrimination among non-nuclear-weapon states, or simply accepting the risk that technical barriers will soon disappear altogether.

No other single failure of the nuclear powers stands out as sharply, however, as the failure to negotiate a Comprehensive Test Ban Treaty. The United States, the United Kingdom, and the Soviet Union have been holding forth in Geneva for half a decade, neither making much progress themselves nor allowing non-nuclear-weapon states to participate. Yet the Comprehensive Test Ban Treaty is of central importance to international norm building. Not only would its ratification demonstrate that the nuclear-weapon states were at least concerned, if not alarmed, about the continuing nuclear arms race but, since the Treaty would be open to all countries on an equal basis, it would be inherently non-discriminatory, and would provide a second channel for reinforcing the norms against nuclear weapons in a way that is completely separate from the peaceful nuclear fuel

cycle. And last, but far from least, a complete prohibition on nuclear explosives would vastly complicate the planning of any potential proliferator, since even a test such as India's would become a formal violation of both the treaty (if signed) and the norm.[11]

Conclusion

With regard to the nuclear fuel cycle, there is only a narrow and precarious path open to strengthening safeguards. It is very doubtful that there will be any major change in the orientation of the International Atomic Energy Agency and the safeguards system it administers, since its objective has been to promote rather than to retard the diffusion of technology. There seems to be no way to act on the basic principle that the riskier an activity is, the stronger the safeguards must be. Even if there were a way, we would still expect to move increasingly — though more or less slowly depending on the technical and economic future of the nuclear industry — towards a world where many countries will be able to produce and test a nuclear weapon in a very short time, a time much shorter than that needed to mobilize the political resources required for the imposition of sanctions or any other preventive or punitive action.

Unless that world is one in which there are not only measures aimed at specific motives and specific cases, but also strong and consensual international norms against nuclear weapons, it will be subject to "proliferative instability," where the failure to restrain proliferation in even a single case can lead to a rapid recalculation of security interests and motivations that will start a chain of further proliferation that will be very difficult to limit or contain.[12]

A shift in the policies of the United States and other nuclear powers to a more political approach, as suggested here, will be of limited credibility and dubious value unless it is accompanied by actions to limit vertical proliferation, and by visible changes in the attitudes and behavior of the nuclear-weapon states to support and strengthen the international norm. Otherwise, the main barrier to the further spread of nuclear weapons will remain primarily the individual motives, intentions, and self-interests of the rapidly increasing number of nuclear-capable countries — a thin and brittle barrier indeed in the Middle East, Southwest Asia, and even the Far East over the next two decades.

Notes

1. An international "regime" consists of a set of generally accepted rules and procedures of behavior, and does not require a formal treaty or the creation of an agency to come into being. See, for example: G. I. Rochlin, Plutonium, Power, and Politics: International Arrangements for the Disposition of Spent Nuclear Fuel, University of California Press, Berkeley and Los Angeles (1979), Chapter 7.
2. Two important books from this period are: R. Rosecrance, ed., The Dispersion of Nuclear Weapons, Columbia University Press, New York (1946), and L. Beaton and J. Maddox, The Spread of Nuclear Weapons, Praeger, New York (1962).
3. The Chinese test at Lop Nor in 1964 was certainly a contributing factor as well, but it was a fait accompli by 1965, and the Soviet Union had already tightened up considerably the conditions of fuel and technology transfers to its allies — a policy that it has maintained to the present day. From review of various documents of the mid-1960s, it is clear that those who were negotiating the NPT from both sides had advanced countries such as Germany uppermost in their minds. The risks of proliferation among the less-developed countries were considered to be small and remote in time.
4. Article IX, para. 3 of the NPT defines, "for the purposes of this Treaty," a nuclear-weapon state to be one that had exploded a weapon or other nuclear explosive device prior to January 1967.
5. Neither Israel nor (at the moment) India now expresses an interest in joining the non-proliferation regime, but that is no reason to block their path for the future. In principle, even a country that has an announced nuclear weapon capability can someday foreswear it, declare its fissile material inventory, and join the NPT as a non-nuclear-weapon state pledged never to exercise that capability thereafter. (Presumably, the original five states are exempted.)
6. The sequence of events as set out here is clear from the history of documents and negotiations. The first real progress toward the NPT began in 1965, when the United States and the Soviet Union submitted almost identical drafts of the treaty to the Eighteen-Nation Disarmament Committee. These drafts addressed themselves almost exclusively to prohibitions on the acquisition of nuclear weapons by non-nuclear-weapon states. Delineation of the new safeguards system was deferred until

1967, and the group of experts called to design the new system had not completed their work even by the time the Treaty was offered for signature in 1968. See, for example, E.C.B. Schoettle, Postures for Non-Proliferation, Taylor and Francis for SIPRI, London (1979).

7. M. J. Brenner, Nuclear Power and Non-Proliferation: the Remaking of U.S. Policy, Cambridge University Press, Cambridge (1981), has an excellent discussion of the post-1974 political turmoil.
8. "Report to the American Physical Society by the Study Group on Nuclear Fuel Cycles and Waste Management," Rev. Mod. Phys. 50, January 1978 (Special issue). The "model" 1000 MWe LMFBR discussed therein requires the entire plutonium output from 43.8 GWe-yr of operation of a typical enriched-uranium fueled LWR.
9. J. Prawitz, "Sweden — A Non-Nuclear-Weapon State," in Johan Jørgen Holst, ed., Security, Order, and the Bomb, Oslo, Universitetsforlaget (1972), is probably the best discussion of Sweden's nuclear option and its abandonment in favor of the NPT.
10. Webster defines "proliferation" as a vegetative process: "growth by rapid production of new parts, cells, buds, or offspsring". In those terms only the "vertical" arms race between the superpowers thus far deserves this title. Nevertheless, the fact that nuclear weapons have spread only slowly thus far should not be a cause for complacency. Until quite recently, the majority of non-nuclear-weapon states did not have sufficient technical potential to make possible the rapid spread of nuclear weapons technology among them.
11. G. Smith and G. Rathjens, "Reassessing Nuclear Non-Proliferation Policy," Foreign Affairs, 59, 875 (1981), presents a persuasive case for a Comprehensive Test Ban Treaty within the current context.
12. A small but significant body of literature argues that further proliferation may not be a serious problem, because the superpowers will be able to contain its effects and will themselves remain relatively safe from direct harm. Some have even argued that the costs of proliferation may be less than the costs of trying to restrain it. See, for example, K.N. Waltz, The Spread of Nuclear Weapons, Adelphi Paper No. 171, International Institute for Strategic Studies, London (1981). Nonetheless, most of these analysts agree that the case they

are considering is that of relatively slow, rather than rapid, proliferation. The view taken here is that without further strengthening of the norm, rapid proliferation will be the more likely outcome. Moreover, a shift to a strategy of "managing" proliferation rather than attempting to prevent it will probably entail relaxing some of the prospective sanctions (because cooperation is the most effective management strategy), thus lowering the barriers further. On balance, a strategy of active prevention, combined with serious efforts to reduce threats and capabilities that already exist, or are rumored to exist, is the less risky course in the long run, for a management strategy can always be adopted if measures for prevention ultimately fail.

Vertical Proliferation:
The Nuclear Arms Race of the Superpowers

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Introduction

This presentation relates specifically to the nuclear arms race between the United States and the Soviet Union, often referred to by the technical term "vertical proliferation". My purposes are to review some of the most pertinent facts and data about the arms race, to describe some systematic relationships among these facts and data, and to draw some specific conclusions from these relationships. This does not include a discussion of the very important related subjects of the effects of nuclear war and the problem of nuclear overkill. Nor does it include a discussion of the precise balance of nuclear weapons strength between the two superpowers, either in regard to how that balance came about or what its future course is likely to be.

Although the history of the U.S.-U.S.S.R. arms race has typically been characterized by extreme changes and fluctuations, three remarkably constant features also emerge. In the following, we describe these constants of the arms race, conjecture about the reasons for them, and try to draw some conclusions from them. The three constants are:

1. The rhetoric of the Soviet-American relationship, which has scarcely changed in 35 years;
2. The number of strategic nuclear delivery vehicles in the United States arsenal, which has remained essentially constant since the Korean War;
3. The expenditure level of the Soviet Union on strategic armaments, which has been about the same fraction of their GNP since 1964.

Constant 1: The Rhetoric of the Arms Race

In 1950, a document written by the U.S. National Security Council (NSC Report 68) describes at length the U.S.-Soviet situation as then perceived, and concludes in a very pessimistic tone about Soviet capabilities and intentions. Quoting in part from that document:

> "The Soviet Union is developing the military capacity to support its design for world domination. The Soviet Union actually possesses forces far in excess of those necessary to defend its territory. Should a major war occur in 1950, the Soviet Union and its satellites are considered by the Joint Chiefs of Staff to be in a sufficiently advanced state of preparedness immediately to undertake and carry out campaigns to overrun western Europe, to launch air attacks against the British Isles, and to attack selected targets with atomic weapons in Alaska, Canada, and the United States."

As a measure of how desperate the authors of this report felt the situation was, they concluded that a large measure of sacrifice and discipline would be demanded of the American people, who "will be asked to give up some of the benefits they have come to associate with their freedoms." This desperation concerned a situation that was expected to develop within the next few years after 1950.

Only seven years later, the highly publicized Gaither report concluded that:

> "The evidence clearly indicates an increasing threat which may become critical in 1959 or in early 1960. The evidence further suggests the urgency of the proper time phasing of needed improvements in our military position vis-a-vis Russia. The singleness of purpose with which they have pressed their military-centered industrial development has led to spectacular progress. They have developed a spectrum of A- and H- bombs and produced fission material sufficient for at least 1500 nuclear weapons and they have probably surpassed us in ICBM development."

The Gaither report called for a large number of emergency measures for the United States, including, particularly, a national civil defense program.

By simply changing a few of the nouns in these reports, one could convert them into reports that are in wide circulation today, and that deliver essentially the same message. For example, the

terms used today to present the problems of "Minutemen vulnerability" and the "civil-defense gap" are remarkably similar to those used to describe other gaps over and over again for the past 35 years. Also for all these years, the predictions of these reports have been wrong. Of course this does not prove that similar predictions are wrong today, but it does mean that a healthy degree of skepticism is warranted regarding contemporary predictions about the future of the U.S.-Soviet situation, even when they are made by very prestigious individuals or groups.

Perhaps some skepticism is also warranted about the credibility of people who have made dire predictions in the past that have always proved to be incorrect, and who continue to make such predictions. If you live in a place where there are many wolves, the person who says every day that there will soon be a wolf at your door may turn out to be right some day, but this is not a person whose insights into the future would, or should, inspire your confidence. Yet some of the same people who have been saying such things in the United States, and who authored reports such as those quoted, are still in positions of considerable influence with respect to American defense policy.

Constant 2: The Arsenal of Strategic Weapons

The strategic nuclear arsenals of the United States and the Soviet Union are usually described in terms of type of vehicle, type and size of warhead (megatons), number of delivery vehicles of each type, vehicle speed, accuracy, details of construction, and so on. Of these factors, the number of strategic delivery vehicles is the one that receives by far the most attention in U.S. Congressional budget hearings and other internal debates, as well as in the Strategic Arms Limitation Talks (SALT) between the two countries.

Shortly after the Korean War, one of the nuclear policies of the (then) new Eisenhower Administration that were being developed was the so-called policy of "massive retaliation", which implied a full-scale U.S. nuclear response in the event of a serious Soviet expansionist move. At that time, the actual implementation of the U.S strategic arsenal jelled in such a way that the number of strategic nuclear delivery vehicles came out to be just under 2000. Today, a quarter of a century later, the number of delivery vehicles is 2200, and, in fact, since 1955 this number has not deviated from 2200 by more than about 5% on the average, with a maximum

deviation of only 9%. The latter occured when the number went up to 2400 for a period of about one year following the Cuban missile crisis. Thus, over a 30-year period during which almost everything else that relates to the arms race fluctuated and changed wildly, the number of U.S. strategic nuclear delivery vehicles remained essentially constant.

Although it is not easy to understand why this number has remained so steady, the history of how it came about is more straightforward. The number was determined not from strategic nuclear thinking, but as the result of an internal debate and compromise between the bomber generals from World War II and the government's budget directors. The bomber generals, who had designed and carried out the air war against Germany and Japan, thought in conventional World War II terms of the large numbers of bomber aircraft required for penetration in sufficient force to overwhelm defenses. They were applying this traditional experience to the utterly different and unprecedented situation of nuclear weapons, and were thinking in terms of large numbers of wings, squadrons, and aircraft. The budget directors, naturally, were thinking in terms of holding costs down. The two groups compromised at a number in the neighborhood of 2000.

Since that time, as already stated, almost every other feature of the nuclear arms race changed dramatically. The first-generation atomic bombs were replaced with hydrogen bombs, with 100 to 1000 times more destructive power, yet there was never any discussion that the number of bombs should be decreased. The total destructive power of the U.S. arsenal thereafter increased greatly, reaching a maximum in about 1960. But it has been decreasing ever since then, because of another factor that was changing rapidly over this period.

At the beginning of the period, the delivery vehicles were mostly B-29 and B-36 propeller-driven aircraft of World War II vintage, with a small number of B-47 first-generation jet bombers. As time went on, jet aircraft, especially the B-52, became a larger and eventually predominant proportion of the bomber fleet. By 1960, ballistic missiles were being deployed: Thor and Jupiter in Europe, Atlas in the United States, and Polaris at sea. At that time, the missiles had much less payload-carrying capability than aircraft, and they could carry only one warhead each. The result of this evolution of bombers to missiles was, therefore, that the number of available megatons of destructive power decreased considerably. In fact it never returned to the earlier level of the manned bomber

period, and today the United States forces have about one-third the megatonnage as they had in 1960.

The number of warheads changed in a different way, first dropping rapidly as the missiles were deployed in the 1960s, then increasing again as multiple- injection reentry vehicles (MIRV) were introduced in 1970, making possible more than one warhead on a rocket. Through all these changes, however, the number of delivery vehicles remained essentially the same; every time one new missile was introduced into the force, one old airplane was removed. Although there have been numerous suggestions that the number of delivery vehicles should be altered as the result of the many other changes that had occured, including the greatly increased accuracy of recent systems such as the Cruise, this in fact never happened.

The political situation was also changing radically. At the time when the doctrine of massive retaliation was formulated in the early 1950s, a widespread belief existed in the United States that there was a monolithic Sino-Soviet bloc bent on territorial expansion, and further that this country would be forced to employ technological means to cope with a massive ground-force invasion of Europe. In 1960, of course, the Sino-Soviet bloc disintegrated, but even so great a political change as this did not cause a significant change in U.S. missile strength. The one event that did precipitate a small change was the Cuban missile crisis: a slight increase of 9 percent in the missile force occured because President Kennedy decided that at that particular time removing B-47s from the force would send a reassuring signal to the Russians, so there was a period when B-47s were not being decommissioned as rapidly as Minutemen missiles were being brought on line. Evidently this did not make much military sense, and within one year a sufficient number of B-47s were decommissioned so that the number of missiles came back to 2200.

Other important political developments were taking place. The United States and Soviet Union entered into a period of political detente. Yet the missile force did not change. The Strategic Arms Limitation Talks got underway. The missile force did not change. In fact, the basis for the figures brought to the SALT discussions was the existing force, and the plan of SALT was to continue the force at this level for an indefinite period.

It is interesting to contemplate why the U.S. missile force should have remained essentially constant through the many important and relevant political and military changes that were taking place in the 1950s and 1960s. If the succession of strategic

analysts and operations analysts through that period thought that they were actually deciding what the force would be, they were wrong, as no succession of plans that took into account all those changing circumstances would have, as if by magic, all come up with the same number — 2200. The people who thought that they were planning the force were actually rationalizing it.

Another example of rationalizing concerns the way the target system for the U.S. missile force seems to be derived. One might assume that in reasonable strategic force planning, the number of targets of strategic importance would first be defined, and then the force would be appropriately designed relative to that number. But this is not the way it has actually worked: the number of targets has in fact become equal to the number of available re-entry vehicles. In other words, the target system is a rationalization of the force rather than vice versa, as it should be. Unfortunately, this has been the case for a long time. As far back as the late 1940s, when David Lilienthal was Chairman of the Atomic Energy Commission, he complained publicly that his job was apparently to produce weapons in the requisite numbers, but when he asked what the requirements were, the only response he ever got was that there should be "more".

Constant 3: Soviet Expenditures in Strategic Systems

Another one of the most important facts, and constants, of the arms race is that the level of the Soviet Union's investment in strategic nuclear forces has since 1964 been an essentially constant fraction of their gross national product (GNP). Therefore, this expenditure slowly but very steadily rises, and apparently does so regardless of what else is happening in the world. We certainly do not know how or why this came about, but it seems no more coincidental than the constancy of the U.S. missile force. Unlike the situation in the United States, however, where the expenditures have fluctuated wildly but the force has remained constant, in the Soviet Union the situation has been the reverse.

During the period since 1964, the Soviets built up their missile force very rapidly for the first ten years, from a few hundred delivery vehicles in 1964 to some 2400 delivery vehicles by the middle 1970s. Since that time, perhaps as the result of the SALT I talks, the Soviet force has not increased in numbers. What has happened instead is that many improvements in and new models of delivery vehicles have been introduced. One result of the Soviet

approach is that the number of models is very much larger than in this country. In the period since 1960 the United States has introduced the Atlas, the Titan, two models of the Minuteman, and now the MX. During the same period, the Russians have moved from the SS5 all the way to the SS25 — essentially twenty different systems, with a number of modifications of each system, in many cases. The Soviet missile design bureaus evidently work at a constant level of effort, constantly turning out new and improved systems. The result of this mode of operation was to increase the number of missiles until the middle 1970s, but since then it has served to introduce a greater variety and also improvements into the system.

Nothing that has happened external to the Soviet Union since the Cuban missile crisis (which probably did have a great influence on the Soviet effort) has appeared to influence their course. Relations with China steadily worsened; it made no difference. Detente came along; it made no difference. SALT came along; it made no difference. Although the SALT negotiations had some influence on Soviet missile deployment, they did not influence the level of Soviet investments in their total strategic program. Now U.S.-Soviet relations have again changed for the worse, with the Soviet involvement in Afganistan, but there are still no signs of any change in the pattern of Soviet investment in strategic systems.

The persistence of the Soviet effort has clearly borne fruit. They have produced a capable development system, and with that they have produced good, high quality equipment. They have reached approximate parity with the United States in the various factors that are important in the nuclear arms race, and they may very well surpass us.

Is There a Way Out?

When we reflect on these three constants of the nuclear arms race, we can only conclude that the arms race really does have a "mad momentum of its own", as former Secretary of Defense Robert McNamara once remarked, and that it is just about as mindless as its most radical opponents say it is, and certainly as dangerous as they say it is. It is not simply that the basic theory underlying the arms race is wrong, rather it is that there is no underlying theory at all.

Ultimately, the solution to the arms race must be found in the political arena, because it arose out of problems that are basically

political. This will have to come about through a very profound evolution of the present nation-state system, which currently is characterized by 160 independent actors with almost no body of law, and absolutely no law enforcement, governing the relations among them. In the meantime, before that millenium arrives, we are obliged to pursue lesser possibilities. One of the most important of these is direct negotiation with the Soviets and others, designed first to put a limit on the arms race, and then to reverse it. Although we have been attempting this course for some 35 years, and do not have much to show for it, the present situation would probably be even worse if we had not been making this effort.

In addition there are certain limited unilateral actions that are perfectly sound, in the sense that they would not reduce national security, and that would move the world in the right direction. One example of such an action would be a pledge of "no first use" of nuclear weapons. Another example would be the elimination of battlefield ("tactical") nuclear weapons, which are designed to be used in actual warfare and have deterrence only as a secondary purpose. It would of course be preferable if both of these steps could be negotiated bilaterally, but even taken unilaterally they would be important steps forward.